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ABSTRACT

Considerable attention has been devoted in recent years to theories of text comprehension and recall that stress the importance of preexisting knowledge structures or schemata. While the valuable contribution such research has made to the understanding of the reading process and the various disabilities that often attend its acquisition must be acknowledged, several shortcomings of schema-theoretic work may restrict its future usefulness. These areas of concern include the specification of component processes and their patterns of co-occurrence in less able readers; individual differences in comprehension style; efficiency of knowledge-based processing (including issues of automaticity, immersion, cognitive economy of representation, and economical deployment of resources); learning (including trans-situational integration and conceptual change); and nondenotative aspects of understanding. (Author/RL)

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CENTER FOR THE STUDY OF READING

Technical Report No. 191

SCHEMA THEORY AND READING COMPREHENSION: NEW DIRECTIONS

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Abstract

Considerable attention has been devoted in recent years to theories of text comprehension and recall that stress the importance of pre-existing knowledge structures or schemata. While acknowledging the valuable contribution such research has made to our understanding of the reading process and the various disabilities that often attend its acquisition, several shortcomings of schema-theoretic work that may restrict its future usefulness are discussed. The areas of concern include the specification of component processes and their patterns of co-occurrence in less able readers; individual differences in comprehension style; efficiency of knowledge-based processing (including issues of automaticity, immersion, cognitive economy of representation, and economical deployment of resources); learning (including trans-situational integration and conceptual change); and nondenotative aspects of understanding.

Schema Theory and Reading Comprehension: New Directions

A large volume of research in recent years has led to the inescapable conclusion that comprehension is a constructive process. By that it is usually meant, following Bartlett (1932), that explicit information in a text is insufficient for the specification of the meaning of that text. Rather, the complete meaning is constructed by combining information from the various sources that comprise the context of the text, e.g., prior knowledge, linguistic, situational, and task contexts. It is this act of combining information to produce a text's understood meaning that is referred to as construction. Of the various impinging contextual factors, a central role belongs to the preexisting knowledge the comprehender brings to bear to inform the understanding of a given text. Along with the realization of the importance of prior knowledge in the acquisition of new knowledge has come a spate of theoretical work concerning the content and organization of knowledge, as well as the processes by which prior knowledge exerts its influence. This work has been carried out under various rubrics including schema (Anderson, 1977; Rumelhart & Ortony, 1977; Spiro, 1977), script (Schank & Abelson, 1977), and frame (Minsky, 1975). For the purposes of simplifying the present discussion, these will all be referred to as "schema theories."

The constructive orientation, with its attendant emphasis on the importance of what one already knows in determining what one will come to know, must be considered an improvement over the narrow "bottom-up"

conceptions that earlier dominated thinking about reading. Nevertheless, if the usefulness of schema theories to those interested in children's reading comprehension is not to quickly reach a point of diminishing returns, I believe more research will have to be initiated in several areas that are currently being neglected. In this paper I sketch my personal view of what those needed directions are.

Specification of Component Processes and Their Patterns of Co-occurrence in Less Able Readers

I sometimes get the impression that people think the main implication of schema approaches is that if a child is having problems with comprehension, they are caused by a deficiency of requisite knowledge. The solution, then, is merely to build in that knowledge. Clearly, availability of appropriate background knowledge is necessary for comprehension, and many reading problems may be traceable to mismatches between background knowledge presumed in a given text and that actually possessed by the reader. However, schema availability is not a sufficient condition for comprehension. Schemata may be available but not accessed appropriately or efficiently. Even when an appropriate schema is brought to bear while reading, it is not automatically the case that it will be used appropriately. More attention needs to be paid to top-down processing difficulties that go beyond schema availability. ("Top-down" may be loosely equated with "knowledge-based," "bottom-up" with "text-based.") We have to say more than that prior knowledge matters. How is prior knowledge used? It is very possible that there are a variety of things that can go wrong in

top-down processing. However, unless we know better what should be occurring, it will be difficult to precisely determine what is going wrong. Thus we need to identify and model the components of the process by which preexisting knowledge affects the comprehension of new knowledge. Toward this end, let me suggest, at a very general level, several aspects of the total process that may form a useful taxonomy to guide further study.

1. Schema acquisition. Where do our knowledge structures come from in the first place? This question continues to puzzle developmental psychologists. Cognitive psychologists of the last twenty years have had little to say about learning. (This topic will receive further attention later.) However, various difficulties could result from problems of schema acquisition. If schemata are not acquired in great enough quantity, they may tend to be frequently absent, leading a child to think that his or her knowledge is not relevant even in those cases where it might be (see the following discussion of "general" schema unavailability). Or if the schemata tend to be insufficiently general and overly tied to personal experience, they may not be readily enough applicable to a sufficiently wide range of situations. Even when an individual has a rich store of schemata, it is unreasonable to think he or she will have a prepackaged knowledge structure for every situation that may be encountered. Sometimes knowledge structures will have to be built (or at least altered) to fit the demands of a given situation (see the discussion of generic cognitive economy of representation). It should be noted, however, that the demands on writers and speakers to be "cooperative" (Grice, 1975) suggest that this problem may

not occur as often as one might think; if it is expected that readers or hearers will not have appropriate prior knowledge to understand a discourse, cooperative communicators are expected to provide it.

2. Schema selection. How does one know which knowledge structure(s) to bring to bear in a given situation (including those situations for which a directly relevant schema does not exist, so that a structurally similar one must be selected and used by analogy)? If a schema is inaccessible, it has the same consequences as if it were not available. If it is not readily and effortlessly accessible, the flow of other aspects of the process may be disrupted (see the section on top-down processing efficiency).

3. Schema instantiation and refinement. As discourse proceeds, the variables or slots in generic structures must receive specific instantiation. That is, we start off with a general model of what a discourse is about, and that model must be progressively refined as more information is received. We probably understand this aspect better than any of the others; see Rumelhart (1980) and Collins, Brown, and Larkin (1980).

4. Schema change and maintenance. Again, as discourse proceeds, different schemata will have to be brought to bear at different times, depending on signals from the text. What may be less obvious is that a schema which has had its relevance clearly signaled at one point in a text will often continue to be relevant long past the point of the original explicit signal. In these cases there may be problems of schema maintenance, which in turn produce problems of information integration across segments of text. (Spiro, Boggs, & Brummer, Note 1, demonstrate the

existence of just such a problem in some children with comprehension difficulty.)

5. Schema combination. In some, perhaps most, cases, individual knowledge structures will not suffice for understanding a given part of a discourse. Rather, schemata will have to be combined. Furthermore, the result of that combination may issue in a product not inferable by an additive combination of its schema parts. Needless to say, such issues of emergence are still poorly understood in psychology.

6. Nonanalytic aspects of schema-based processing. These are discussed in the last section of this paper.

If there are problems with any of these types of processes, reading difficulties may ensue. Unfortunately, we know very little about how they all work. For some, it may even be too much to expect answers to be forthcoming in the near future, because they get at basic questions of cognitive functioning that have resisted solution by philosophers and psychologists since the beginning of recorded thought: What are insight, creativity, thinking? How do these phenomena occur? After all, we now realize that comprehension is a kind of problem solving, but we still are in the primitive stages of discovering where the solutions to complex problems come from.

Once the component processes are identified and we know how they operate, we can then ask more precise questions about what might go wrong in children having difficulty comprehending. Do they generate too many hypotheses about what a text is about (i.e., which schemata are appropriate

for its understanding)? Too few? None? Are hypotheses, once generated, characterized by inflexibility when they have to be changed? By inertia? Do they access their schemata too early, prematurely locking themselves into interpretations that are not warranted by the data of the text? Or do they wait too long, so that by the time a schema is selected much of the previously read information has been forgotten because it lacked an organizing framework? Is text content inappropriately mapped onto generated hypotheses? Are hypotheses inappropriately evaluated, with little or no checking to see if subsequent parts of the text fit (see Brown, 1980)? When we better understand what comprises the process, we can then systematically attack the important question of where the seams in the process are. What problems tend to co-occur, forming unified deficiency syndromes? (This is a question that has been asked before, e.g., in the various factor analytic approaches. The problem is that a component model corresponding to schema-based processing has never been incorporated into such an analysis.) To what extent are breakdowns idiosyncratic? Does the same individual tend to have the same or different breakdown patterns across situations, types of material, levels of difficulty of material, etc.?

Naturally, the recommended attention to the components of knowledge-based processes must be complemented by further investigation of the composition of the knowledge structures themselves. In particular, it would be nice to know what is in common across the efficient representation of knowledge in the various subject area domains, and how the representations of individuals can be assessed.

In a sense, each of the remaining sections also deals with deficiencies in our knowledge of the specifics of the contribution of prior knowledge to comprehension. They differ from this section in that they deal with particular problems; the current section was intended to argue for a more detailed inquiry into the components of the entire process and their interaction.

Individual Differences in Comprehension Style

Clearly there are differences in the component skills of individual readers that affect their performance. However, a theoretically distinct question that can be asked is whether individuals with comparable reading skills all read the same way. Here the question is not so much concerned with differences between more and less able readers, as with differences in comprehension styles. Despite the fact that constructive processes in comprehension have been the subject of continuous investigation for over ten years now, there has been next to no consideration of individual differences in that vein. If someone who accepted the constructivist premise were to ask whether everyone did it in the same way, there would be no basis for a reply. This is particularly surprising given the emphasis in constructive theories on personal contributions of the comprehender, and the use of more natural and personally relevant sorts of stimuli that have characterized the movement away from the isolated materials of the verbal learning tradition.

Recent work has shown, however, that all those with comparable reading skills do not process text the same way. Rather, individuals differ in the way they allocate their limited capacity processing resources. As we have

repeatedly seen demonstrated, reading comprehension is an interactive process (for a review see Adams, 1980). What we already know informs in top-down fashion information from text that is being processed from the bottom-up. At the most general level, some individuals seem to rely more on the contributions of text to understanding; others stress processes based on what they already know. This is true of adult skilled readers (Spiro & Tirre, 1980) and of children who are far from maturity as readers (Spiro, Tirre, Freebody, & DeLoache, Note 2). For the former, the pattern is frequently one of an optional distribution of processing in a preferred direction, with little effect on success of performance. For the latter, the problem sometimes appears to be more serious, with maladaptive patterns of overreliance manifest.

The instructional implications of such findings, if the interpretation continues to be validated by future research, appear to be profound. Common sense would suggest that the most effective strategies for correcting the problems of individuals with one type of style would be exactly the opposite of what would most help children with the other type of style. For example, if a child is overreliant on the text, instruction should seek to enlighten the child as to the importance of using prior knowledge as a context for understanding. However, the child who is not paying enough attention to the text will find his or her problem reinforced by instruction that stresses using prior knowledge more! Hence a failure to consider individual differences in reading comprehension styles in the classroom may lead either to helping some while hurting others or, if a middle road is adopted, providing optimal help for nobody.

The story on discourse processing styles does not stop with the dichotomy just discussed, however. One must also consider the etiology of an individual's style (Spiro, 1979). A given style can result from a variety of causes, and each might imply its own preferred treatment. Consider the case of overreliance on text-based (or bottom-up) processing:

1. A child may lack the requisite schema for understanding particular passages. Clearly, in those cases where knowledge is not available, it cannot be applied. I call this local schema unavailability. On the other hand, a child may tend to be knowledge-deficient across a range of situations, which I refer to as general schema unavailability. In the latter case, a text-based reading style may develop.

2. As we have already indicated, skills and styles are considered to be part of a two-tiered model of individual differences. That is, skills are not considered to be perfectly determinate of styles or vice versa. In general, a given skill deficiency should be able to result in either processing style depending on whether the child perseveres in the problem area or attempts to escape and compensate. For example, consider a child who is slow and who expends a great deal of effort at word identification. Such a child may persevere at decoding, utilizing so much of available processing capacity that other, higher order, comprehension processes may suffer from the ensuing "bottleneck" (Perfetti & Lesgold, 1978). On the other hand, a child with such a problem may try to escape from the unpleasant task for which he or she possesses so little skill by doing other things to compensate. Here the child may come to rely on top-down

processing to guess at many of the words in a text. The same indeterminate reaction would apply to a deficient top-down processing skill, e.g., ineffective schema selection. The child could work harder at identifying requisite background knowledge, detracting from bottom-up processing, or escape by overrelying on bottom-up processing.

3. Some children seem to have a misconception about reading (Canney & Winograd, 1979; Spiro & Myers, Note 3). They think that reading is a bottom-up process, and that top-down, extra-textual activities are inappropriate. Such a child may develop a bottom-up bias because that is what the child thinks he or she is supposed to do. We know very little about children's conceptions of reading and even less of their causes. However, reasonable candidates with respect to bottom-up biases include code emphases in early reading instruction, insular and irrelevant reading texts, and tests that stress literal content at the expense of its integration with relevant preexisting knowledge.

4. Some individuals seem to have general cognitive processing styles that dictate their discourse processing style. For example, some people have difficulty overcoming the closure of a geometric stimulus configuration in order to detect a memorized target configuration within it. These people are said to be stimulus-bound, lacking in freedom from Gestaltbindung (Thurstone, 1942), or field dependent (Witkin, Moore, Goodenough, & Cox, 1977). This style of stimulus-boundedness generalizes to a variety of situations (Witkin et al., 1977). Does it generalize to text, where a structure from memory (a schema) must be superimposed on a more external

stimulus structure (that of the text)? Spiro and Tirre (1980) found that to indeed be the case. College students scoring lower on an embedded figures test (with vocabulary scores statistically removed) used their prior knowledge less in the performance of a discourse processing task.

5. Sometimes there may be small areas of breakdown or "bugs" in a child's processing routine that create the appearance of an overreliance on the text. For example, we have found (Spiro, Boggs, & Brummer, Note 1) that some children have difficulties with schema maintenance across sentences (for reasons other than forgetting the earlier information). However, top-down processes within sentences are carried out adequately. Hence the top-down processing apparatus of these children is intact and operative, but a bug keeps them from demonstrating it to full effect. I would call such instances "pseudo-styles."

The pilot study by Spiro et al. (1979) found that three of these etiological factors (decoding skill, cognitive style, and general schema availability) were somewhat predictive of discourse processing style in fifth- and sixth-grade children. However, all of the preceding discussion must be considered conservatively. More work needs to be done to demonstrate the reliability, validity, and range of application of these findings across types of tasks and texts. Their potential practical importance, however, should make the study of individual differences from a constructive viewpoint a major priority in reading research.

Efficiency of Top-Down Processing

A point often overlooked in schema-theoretic research is that individuals may be able to execute the various processes of comprehension under some set of ideal conditions, but have difficulty under the real-time constraints of reading in natural settings because some of the processes are not executed efficiently. Efficiency is a topic that has received considerable attention with respect to bottom-up processes following the paper by LaBerge and Samuels (1974) on automaticity (see also the demonstration by Perfetti & Hogaboam (1975) of the importance of rapidity of decoding). Unfortunately, there has been almost total neglect of top-down processing efficiency, despite the fact that inefficient top-down processing can, in principle, contribute as much to reading deficiency as inefficiencies in word identification. In this section we consider several aspects of top-down processing efficiency: automaticity,[1] cognitive economy of representation (episodic and generic), and cognitive economy of resource deployment. As a general point, any of the processes discussed earlier in the section on components should be capable of efficient or inefficient execution. For example, schemata can be selected rapidly and without requiring conscious awareness, or selection may occur only after a process of effortful, self-conscious consideration.

Automaticity

The point for reading instruction again involves our limited capacity as information processors. There is a limit on the number of things we can devote conscious attention to at a given time. If much of this capacity

must be used for processes of word identification, a bottleneck will be created that inhibits other important comprehension processes (cf. Perfetti & Lesgold, 1978). On the other hand, to the extent that word identification can proceed without requiring conscious attention (or at least rapidly), more capacity will be freed to do such things as think about what one is reading. Note, however, that much top-down processing may also be automatic (with similar ramifications regarding limited processing capacity). As adults, if we read The child was carelessly playing with the delicate pitcher and it suddenly fell to the floor, an inference about it probably breaking will typically be made without requiring any conscious effort. As an exercise, read a prose passage as you normally would. Think about what it all meant when you are done. Then go back and see how much additional meaning you imported to the text without having been at all aware of doing it. Such examples of automatic top-down processing are ubiquitous. We tend to no longer be aware of it because of the high level of skill we have achieved. But a child may not be doing as much automatic top-down processing as we take for granted.

Any of the components of schema-based processing that were discussed in an earlier section can be executed automatically or not. For example, where we would automatically select a schema to inform our understanding of a given text, an inefficiently comprehending child might have to labor over the question of what the text is about, what already-possessed knowledge must be brought to bear to understand it, etc. Such conscious attention to what could be an automatic top-down process can have as severe consequences

for the flow of text processing as laborious decoding. (Note, however, that it is not necessarily the case that more attention to one process will produce interference with other processes--mutual facilitation is always another possibility.)

Unfortunately, we know little about how processes below the level of consciousness operate, perhaps because their unavailability to introspection make them more difficult to form hypotheses about and subsequently investigate in rigorous fashion. Philosophers have devoted some attention to the question (e.g., Polanyi, 1966). Some speculations based on psychological models are possible (e.g., default nodes in schemata may be activated whenever their superordinate structures are; see Schank & Abelson, 1977, and Spiro, Esposito, & Vondruska, 1978). In general, however, there is little we can say conclusively on this matter.

Issues get fuzzier still when one thinks of a special kind of automaticity--immersion. Often when we are reading we become so involved in what we are reading that we forget that we are reading. This is the commonly experienced feeling colloquially expressed as "getting into" something. Yet, if we pay more attention to the details of our reading, the process suffers. Although it seems intuitively obvious that there are advantages of such a processing mode, we have little idea of what they might be, much less how the ability to immerse develops, its preconditions, or even what is going on when you are immersed that is not going on when you are not. I would venture one speculation: It is something more than an ability to execute more conventional analytic-type mental activities as a

benefit of freed-up information processing capacity. Rather, the processing seems to be of a very different kind; there is a greater sense of directly experiencing what is being read. One "feels it more." The role of such feelings in cognitive processing, an unexplored topic since Bartlett proposed his concept of attitudes, is discussed in the last section.

Cognitive Economy of Representation

Much of the information that we encounter is at least imperfectly derivable from other information already represented in memory. Does such derivable information receive an independent and durable representation in long-term memory? Results of an experiment by Spiro & Esposito (1977) indicate in the negative. For example, if skilled reading adults read that a karate champion hit a block during a demonstration, and they then read that the block broke, the latter information can be shown not to be explicitly represented in memory shortly after reading. When information is subsequently presented in the story that vitiates the force of the derivability of the predictable information (e.g., the karate champion was having trouble concentrating because of a fight with his wife that day), thus blocking its derivation if it was not stored, skilled reading adults tend to say either that it did not say in the story whether the block broke or that the block did not break. Furthermore, they are as certain about these errors as they are about accurate memories. Such errors do not occur when the target information is made less predictable, and they can be shown not to be due to representing the predictable information and subsequently modifying that representation when the vitiating information is encountered.

I would argue that minimizing representation where possible (probably not intentionally) contributes to efficient discourse processing. Much of the information we take in will either be used infrequently in the future or not at all. In that case it is more economical to lessen the cognitive effort expended toward complete encoding. If information may be derived from already encoded information (even imperfectly), then it may receive less processing attention and be left to be derived later if it is needed rather than having to devote time and processing capacity to over-elaborately encoding it. This has the advantages of not cluttering up mental representations (perhaps facilitating the retrieval of information) and, more important, of freeing time and capacity for thinking more about what one is reading rather than thinking about how to remember what one has read! It is possible that some children's apparent discourse processing problems may be traceable to uneconomical representation strategies (see, for example, the earlier discussion of text-biased processing styles).

The cost of cognitive economy is occasional inaccuracy in remembering. As a matter of fact, some children may have representations that are too sparse. That is, they may overestimate the future derivability of information. Consider the often heard plaint that material that seemed solidly encoded when studying for a test was a blank when the test actually arrived. Although we have no data yet on the existence of such a strategy, it would fit with a commonly observed tendency even in the most skilled of information processors to make inappropriate use of existing knowledge to estimate the future likelihood of events (Kahneman & Tversky, 1973).

Particularly relevant is the finding of Fischoff (1975) that individuals presented with answers to questions tend to overestimate the probability that they would have been able to generate the answers themselves had they not been provided. Might not, in similar fashion, some readers tend to erroneously think that explicit information in text, once encountered, was "obvious," and thus may be superficially processed?

One thing that enables accurate cognitive economy of representation is the development of highly ramified knowledge structures. The larger the cluster of mutually implied information, the greater the number of opportunities to leave information to be derived later if needed. Again, poor readers may have difficulties capitalizing on potential cognitive economies, now because of the way their knowledge is organized.

I call the kind of storage economies just discussed episodic cognitive economy. That is, they concern the representation of particular, detailed information. A related phenomenon can be called generic cognitive economy of representation, a notion like that occasionally proposed for the representation of individual words in "semantic memory" (cf. Collins & Quillian, 1972). First some background. Much of the modeling of knowledge structures has taken the direction of proposing precompiled (i.e. already assembled) packages of information. An example is the scripts of Schank and Abelson (1977). It does seem to be the case that holistic sorts of knowledge are brought to bear to understand, for example, a trip to a restaurant; it is what permits the episode to be appreciated as a connected activity and enables missing elements to be imported in the constructive

manner. Also, the psychological reality of scripts has been confirmed empirically (Anderson, Spiro, & Anderson, 1978; Bower, Black, & Turner, 1979). However, to say that knowledge may be brought to bear as a whole is not the same as to say that that knowledge is represented in compiled fashion when not being used. An alternative is that knowledge is stored in more fragmented form and is assembled when (and as) needed, in a kind of ongoing programming of prior knowledge (Schank, 1979; such fragmentation was suggested by earlier schema theorists like Rumelhart & Ortony, 1977, in discussions of hierarchical aspects of representation and knowledge embedding). A virtue of this latter organizational principle is that it answers a critical question often asked of schema theories: How can you have a prepackaged knowledge structure in your head for all the situations you will encounter? The answer then becomes that you don't. Rather, the knowledge structures are (re)built to fit the needs of the subtly changing variety of situations that they must help inform, thus permitting greater flexibility in their application. The efficiency point here, besides whatever advantages may accrue from lessening storage requirements, relates to the variable quality of fit that will exist between the purposes of understanding in some situation and the knowledge brought to bear for those purposes. The more degrees of freedom available for adjusting the knowledge context, the greater the potential for more optimal fit. An analogy may be drawn to posture, which is endlessly fluid, yet very accurately recognized. We have knowledge structures that permit us to take the variety of external signals that we receive and integrate them to form a background for an

understanding of the current "postural scene." If rigid knowledge structures had to be used to recognize the infinity of postures, in their infinity of preceding contexts, the process could not work nearly as well as it does. Perhaps then, the same is true for text understanding, as well as any other activity in which humans demonstrate their characteristic symbolic flexibility. It is interesting to note that the schema model of postural recognition proposed by Head (1920) was an important antecedent of Bartlett's theory.

How is knowledge organized to permit such flexibility? Obviously, we have little idea at this time. A simple hypothesis may, however, be proposed. Knowledge structures that are used as wholes (e.g., knowledge about trips to restaurants) are composed of aspects or scenes of two types: those fairly unique to the event (e.g., ordering food) and those that are in common with other events (e.g., eating food). Those aspects that are shared across types of events might then be stored in a single common location, rather than being repeatedly represented with each type of event (artificial intelligence programs operating on this principle are being developed by Schank, 1979). Each of the events that share the structure would have pointers to the shared location where more information is available. Generic event knowledge would then be compiled by combining those aspects of the decomposed knowledge structure that are unique with those shared ones that are <u>needed</u>. Note that for events that are less routinized than going to a restaurant there would be more degrees of freedom for adaptive flexibility in the way the ongoing <u>construction</u> of prior knowledge occurs.

(Clearly, the details of the compiling process have been left largely a mystery. However, since it surely would be conceded that we have the ability to build knowledge structures over some period of time, why would the time available during comprehension be, in principle, insufficient? What must be avoided is a permanent recourse to explanation by mysterious, homunculus-like constructs.)

What would be the implications of such a reconceptualization of the nature of knowledge organization for reading instruction? For one thing, it might suggest an emphasis on knowledge assembly, in addition to that already placed on knowledge availability. The problems one looks for are constrained by one's theories. What new problems might be suggested by a theory of decomposed schemata that are assembled in ongoing fashion? Two come immediately to mind. Some children may store too much generic knowledge in rigidly precompiled form, reducing the ability to adapt flexibly to the subtleties and nuances of difference from one superficially similar situation to the next. If a given text does not fit the tightly prescribed formulas inscribed in memory, it will be less than optimally understood. For other children perhaps there is inappropriate generic cognitive economy; i.e., knowledge is decomposed in such a manner that recomposition is inhibited. Finally, some children may lack the processing apparatus to handle the increased demands placed on compiling knowledge when and as is needed.

Economical Deployment of Resources

This is an area of reading efficiency that has received some considerable research attention and therefore is not discussed here. Very briefly, the important aspects include selectivity--paying appropriate amounts of attention to different parts of text as a function of contextual factors (Reynolds, Standiford, & Anderson, 1978), as well as the computability/derivability of information (Spiro, Esposito, & Vondruska, 1978)--and interactive flexibility (e.g., shifting resources between bottom-up and top-down processes as a function of such characteristics of text and context as familiarity, syntactic complexity, etc.).

Learning

The movement away from behaviorism in cognitive psychology, for all its virtues, has had an unfortunate consequence. We are now able to talk about states of knowledge, and processes that operate on those states; the unfortunate concomitant to this static orientation is that there has been very little new thinking in the constructive paradigm about the process of moving to new structural states, i.e., learning. It is suggested that, in addition to the attention we have been paying to how knowledge affects the processing of text, we need to be concerned with how the processing of text affects the development of new knowledge. Two aspects of the neglected topic of learning will be discussed: trans-situational integration and conceptual change.

Trans-Situational Integration

When you are reading the latest installment in Newsweek about the energy crisis, if you have been following it in the past, you will probably not endeavor to form a complete insular representation of the article as your goal of understanding. Rather, your goal will probably be to integrate what you are reading with what you already know of the subject, with special attention to information that is new. That is, your goal of reading is to update your knowledge. Knowledge updating is not automatic; it is under strategic control. Sometimes, rather than integrating related pieces of information across the situations in which they are encountered, information is compartmentalized by acquisition situation.

This tends to happen with material to be remembered in memory experiments under conventional instructions and with the typical esoteric and/or useless prose materials employed (Spiro, 1977). The danger is that it may also be happening in the schools. This would not be very surprising given the fact that the kinds of tests that are most convenient to construct, administer, and grade also tend to reward compartmentalization. There are situations, of course, where it is desirable to maintain the particular identity of a given text. For example, law students must try not to blend various cases that bear on a given issue. However, in many school situations, a knowledge updating mode would seem to be preferred. A child is exposed to information about the Civil War on many occasions during his or her schooling. I doubt if many educators would want the information about the Battle of Gettysburg contained in a seventh-grade history text to receive its own insular

representation rather than being integrated with other knowledge already possessed about that battle, the Civil War, war in general, and perhaps interpersonal relations and the plight of man. The questions that must be addressed include: How is trans-situational integration promoted? Answers provided by experimental psychology up to this point are minimal, e.g., that using the same wording promotes integration--see Hayes-Roth and Thorndyke (1979). When should it be promoted? What are the costs of integration? (These will certainly include a certain amount of forgotten detail not sharing the organizing principle of the body of information being integrated with.) What are the consequences of failures to integrate? Beyond the obvious consequences of compartmentalization, e.g., that knowledge of a given topic will be hopelessly diffuse and that specific information may be harder to locate if more locations are potential repositories (see the earlier discussion of efficiency and cognitive economy of representation), failure to integrate may lead an individual to miss some crucial connections between pieces of information that are necessary for conceptual change to occur, a topic we will now consider.

Conceptual Change

There are a variety of kinds of learning. One kind that cognitive psychology is fairly adept at dealing with is the type that involves incorporating new information into existing structures without thereby substantially altering those structures. This is like what Piaget has called assimilation. Arguably, a more interesting kind of learning in the educational process involves the radical restructuring of existing knowledge

as a result of encountering new information, what might be called conceptual change or, after Piaget, accommodation. Becoming more expert in any domain involves more than the mere accretion of information (Bransford, Nitsch, & Franks, 1977). We have already seen that we understand via mental frameworks or schemata. One thing that characterizes experts is that their frameworks are qualitatively different from those of novices (Chase & Simon, 1973). Such qualitative conceptual change typically brings with it the following characteristics, among others: The interpretation of the significance of new information changes (much as it does in science when paradigms change; Kuhn, 1962); more efficient patterns of selectivity develop; more processing becomes tacit (see the next section), accompanied by greater immersion; and information is processed in larger chunks. We know next to nothing about the processes of conceptual change. It is a question that has resisted solution since (and before) Plato's paradoxes of the Meno. Piaget has described the differences between cognitive states children pass through but has not proposed a satisfactory explanation of how those changes transpire. Neither has anyone else. Perhaps metaphor, with its capability of describing something new in terms of what is already known plays an important role (Ortony, 1975). Unfortunately, it is probably the case that psychology will have to undergo its own "conceptual change" if an understanding of that essential learning phenomenon is ever to ensue.

What Does a Schema "Feel" Like?: Nonanalytic and Nondenotative Aspects of Knowledge Structures

Given the avalanche of research triggered by the revival of interest in Bartlett's (1932) thinking about constructive processes, it is remarkable that a central aspect of that thinking has been totally ignored. I refer to his concept of the "attitude." Perhaps part of the problem was his choice of terms, so easily confusable with the social psychological concept. One's position on abortion is not an attitude in Bartlett's sense. Rather he described the attitude as "a general impression of the whole . .. a complex state or process which it is very hard to describe in more elementary psychological terms . .. very largely a matter of feeling or affect" (pp. 206-207). Such attitudes were given a central place in the constructive process. For example, recall is described as "a construction, made largely on the basis of this attitude, and its general effect is that of a justification of the attitude" (p. 207). If our knowledge of the past includes such attitudes, then those aspects of comprehension that depend on prior knowledge must also be subject to the effects of attitudes. It is worth noting that Bartlett is not the only person to place feelings at or near the center of analysis of cognitive activity. One should see, for example, the philosopher Pepper's (1942) discussion of the contextualist's construct of "quality." The idea is not even original with Bartlett in cognitive psychology, being very similar to Wundt's Gesamtvorstellung (see Blumenthal, 1970), to take just one example. Neurophysiological work on differences in specialization of the cerebral hemispheres suggests the right

hemisphere may play an important role in this aspect of cognition (see Ornstein, 1972, for an introduction to this area). Among educators, Bruner (1962) is one prominent individual who has considered the importance of such phenomena. Another is Broudy (1977).

What are these "signature feelings" (eschewing the confusing term "attitude" for one suggesting that these feelings represent identifying characteristics of knowledge structures)? Obviously we do not know. However, a speculative line might proceed as follows. Consider the act of holding a specific object, such as a ball, in one's hand. Our experience of that act has diverse aspects. One of those aspects is the one that could take the form of a verbal description of the ball: it is round; it is white; it has seams; it is larger than a tennis ball; it feels smooth; etc. Such descriptions seem inadequate, however. They miss the "existential" aspect of the act: what the experience of holding the ball in the hand <u>feels</u> like. It is the feel of experience that allows us to refer <u>metaphorically</u> to the "texture," "color," or "flavor" of an entity or event. It is proposed, then, that experiences possess qualities, such as texture, that permit of being "felt." Likewise, they have properties amenable to verbal description. However, no verbal description could ever capture the quality of the existential feel of an experience, except as a very rough approximation (and vice versa). Now, my proposal is that the preceding dichotomy of aspects of the experience of holding a ball in the hand is extendable by analogy to the "holding" of a concept in the mind! Cohesive concepts, however complex, have properties that can be decomposed and analytically examined. However,

they also are experiences, and as such they have textural, gestalt-like properties that can only be felt. (A distinction should be made between feelings related to the experience of having an idea and feelings related to the content of the idea; within the latter a further distinction can be made between more and less analytical verbally describable properties, like, e.g., the white color versus the smooth feel of the ball).

Work in the schema-theoretic tradition has focused on the structure of knowledge that must be analyzed, rather than on the texture that must be felt. Accordingly, there is very little to be offered as support for these views. However, a body of data concerned with meaning at the level of the individual word is suggestive. Clearly, word meanings have an analytic aspect, which is what lexicographers and semanticists study. However, words have also been shown to have psychological meaning of a far different kind from that studied analytically. I am thinking about the results of research using the semantic differential (Osgood, Suci, & Tannenbaum, 1957), which have demonstrated that much of the variability in judgments concerning words is due to their evaluative connotations. For an exemplary review of other research that suggests a central role for affect in cognition, see Zajonc (Note 4). Please note, however, that the concept of a feeling under discussion, while including affect, encompasses many other nonaffective aspects of feelings, e.g., feelings of somnolence.

Assuming one accepts the preliminary phenomenological evidence for signature feelings, one might still inquire as to their utility. What is a feeling good for? Many things, it seems to me. First, there is the role

designated for attitudes in Bartlett's theory. They are durable qualities of past events, whose appearance precedes and facilitates the retrieval of detailed information ("I don't quite remember what happened in the situation you refer to, but I know it was something sort of unpleasant and puzzling"). In an evolutionary sense, it would appear to be adaptive to remember for the future those situations in which you experienced fear, pleasure, gratification, etc. The attitudes or feelings then remain active in monitoring the reconstructive process; for example, forming the basis for rejection of generations that do not fit ("It seems like that might have happened, but it does not feel right--I have a feeling that it did not happen").

However, their constraining function may be more general. As Langer (1967) has pointed out, we need both models of how things work and images of how they "appear" (by which she meant something similar to what I have been referring to as that aspect of knowledge structures that is holistically felt). Our mental models of things (including the mind) too often perpetuate new paths and directions that we are deluded into thinking are correct by their systematic fit with that which preceded them. We need the holistic image to be able to detect when our models of how things work no longer fit the "look" (feel) that the system was supposed to analytically describe. It is what enables us to say that something which does not appear to create any logical inconsistencies or to violate any of our explicit knowledge of the world nevertheless "does not feel right."

Signature feelings may also have various kinds of efficiency benefits. They are single units or chunks, thought of all at the same time, and they are often thought of rapidly (as when somebody says they have had a "gut reaction"), thus making more parsimonious use of our limited processing capacity. There is another, perhaps more important, sense in which such a mode of processing may be efficient. Where it is not possible to think analytically about two things at the same time, it may be possible to think about one thing while simultaneously feeling several others, as when Broudy (1977) talks of "knowing with" or Bransford et al. (1977) speak of thinking "in terms of" some context. (Of course, this begs the question of what potential informational value is carried by a feeling). Perhaps feelings are more amalgamable than more analytic or denotative entities. If so, feelings and the characteristics of knowledge that enable them may be an appropriate place to start looking for the answer to that important question of conceptual change posed earlier. It may be in the rapid interplay of feelings (so much like the combinatorial idea play that Einstein spoke of) that the source of the creation of ideas, later to receive their analytic flesh and bones, may be found. If so, how sad it would be if it were discovered that the real problem of many readers is that their instruction so automatizes them that they do not develop a feeling for what they read or do not use the feelings available to them in the development of new understandings from reading.

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Footnotes

[1]Technically, automatic processes are those that do not require conscious attention. However, for the purposes of the following highly condensed discussion, we will be somewhat more general in the use of our terms. Thus, in automaticity we may sometimes be including rapidly executed processes that do require some conscious attention.

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